U.S. Department
of Transportation

**Federal Aviation
Administration**

Year 2000 (Y2K) Program Final Report

Prepared by
Aircraft Certification Service

September 20, 2000

FAA-AIR-00-03

EXECUTIVE SUMMARY

This is the Federal Aviation Administration (FAA) Aircraft Certification Service (AIR) Year 2000 (Y2K) Final Report. This report is the culmination of AIR efforts to ensure aviation safety is maintained, and that manufacturers of aviation products continue to produce products which meet their type design data, into the year 2000.

This report provides information detailing why the transition to Y2K may effect software and/or computer applications, and the AIR methodology employed to mitigate the risks associated with Y2K with regard to aviation safety. This report also provides the results of "on-site" assessments conducted by AIR personnel, and the conclusions drawn from those assessments. The activities associated with the implementation of the AIR methodology began in 1998 and were completed with this report.

Implementation of the AIR Y2K Program Methodology began with the development and distribution of the Manufacturers Self-Assessment Survey. This survey was sent to the manufacturers of aviation products and the Civil Aviation Authorities in bilateral countries. In 1998, the Office of the Inspector General (OIG) conducted an audit to evaluate AIR activities with regard to Y2K preparedness. To address the concerns identified by the OIG, the Year 2000 Transition Survey was developed and conducted as part of the ongoing Aircraft Certification Systems Evaluation Program (ACSEP). The completed Transition Surveys where collected by Aircraft Engineering Division, AIR-100, and Production and Airworthiness Certification Division, AIR-200. Analysis of this data revealed three main areas of concern to AIR: the lack of testing, the lack of contingency plans, and risks associated with schedule slippage. AIR was concerned that insufficient activities, in these areas, would increase the potential for Y2K anomalies to effect aviation safety.

The identification of these concerns initiated a reassessment of the AIR Y2K Plan, and resulted in the development of AIR training materials and the conduct of "on-site" evaluations/assessments. Initial assessments were conducted by AIR-100/AIR-200 personnel, and did NOT substantiate the concerns previously identified. However, these assessments identified potential impacts to the ability of the Production Approval Holder (PAH) to maintain their production approval.

AIR developed and delivered the training and tools necessary, to enable the AIR workforce to conduct Y2K assessments of various manufacturing facilities. Each AIR Directorate was responsible for performing all Y2K assessments in their geographical area. Directorate Assessments began in November 1999 and continued through February 2000. Based on recommendations provided by directorate personnel and substantiated by review of the "Y2K Assessment Records," AIR discontinued these assessments in March 2000.

The Y2K Assessment Records were completed by directorate personnel and forwarded to AIR-100/AIR-200 personnel. The data provided from these records, was reviewed and is the basis for the following conclusions. The majority of manufacturers developed facility inventories, conducted risk assessments, and identified critical processes and/or suppliers. Less than half of the facilities indicated that some type of "work around" or change to an existing process/procedure would be implemented as a result of Y2K anomalies. Notification was provided to the appropriate Principle Inspector, avoiding the potential for impacts to the manufacturer's production approval. Issues identified during the assessments were corrected and follow-up activities were identified.

The implementation of "windowing" techniques (reference Appendix C) and the Crouch Echlin Effect (reference Appendix D) remain of particular concern to AIR. These issues are "post" Y2K anomalies, the effects of which can continue well into the future.

Notwithstanding AIR concerns referenced in this report, FAA personnel were pleased with the manufacturers' response to the potential impacts of the Y2K transition. Prior to FAA involvement, many manufacturers had made a "business decision" to update existing systems, delete obsolete software, archive critical historical data, and assess their vulnerability to software date anomalies. We believe the industry's proactive response to the potential Y2K problem led to the positive conclusions in this report.

Federal Aviation Administration
September 20, 2000
Aircraft Certification Service
Washington, D.C.

1. BACKGROUND.

In the early 1960s, computer programmers were faced with a technical dilemma "How could they design an affordable computer that would save/conserve valuable memory space, yet still provide maximum versatility in programming options and input of data?" The solutions implemented by these computer programmers have triggered the basis for the Year 2000 (Y2K) problem. The following examples, of software programming implementations, are susceptible to errors during the transition from 1999 to 2000.

a. Use of two digits to represent the year (e.g. "99" vs. "1999") is expected to be the most common cause of Y2K failures. Computer applications that use/require two-digit date data are susceptible to data errors, due to the inability of the software to differentiate between 1900 and 2000. Failures may occur when manipulating date data, in arithmetic computations, data comparisons, sorting, and input/output to databases or files.

b. Inaccurate calculation of calendar dates (after 28 February), due to uncertainty as to the designation of the year 2000 as a leap year, has further complicated the processing of date data. Erroneous day/month data in addition to errors in the year data increases the potential for computer failures.

c. Various internal date representations of commercial hardware and software components may be incompatible, due to platform limitations. Specifically, the software date data types, which are stored as an increment over some base date, may be unable to perform the arithmetic function due to the inability to interpret the date data. Additionally, the software date data types may roll over (exceed the established increment) and fail due to the capacity of storage registers.

d. The "hard-coding" of values in software routines. "Hard-coding" refers to the design practice of assigning a fixed value, via software programming, to a data field. For example, hard-coding of "19" for the implied century is obsolete after December 31, 1999. If the software program is not remediated (corrected), the computer may display erroneous data (e.g., January 1, 1900).

e. The use of "99" and "00" values, are reserved in the programming of some software applications, to mean "never delete this" or "until this is reached." The processing of two-digit date fields, as the calendar year transitions from 1999 to 2000, may cause errors in these programming applications, due to the misinterpretation of these values.

2. PROGRAM METHODOLOGY.

Aircraft Certification Service (AIR) instituted an assessment and surveillance program, to gain insight into the awareness and planning for possible safety related Y2K anomalies, in manufacturing and production facilities. The AIR focus was to ensure that the manufacturers of aviation products had taken sufficient measures, to alleviate potential Y2K problems that might adversely impact their capability to produce conforming end-items. Specifically, in those instances where the failure of the end-item, to function as required, could compromise the safe flight of an aircraft.

2.1. MANUFACTURERS SELF-ASSESSMENT.

In early 1998, AIR developed a Y2K self-assessment survey and sent it to more than 2000 manufacturers of aviation products. This survey requested these manufacturers to respond to the following:

a. Do the products they manufacture contain embedded software and/or digital equipment?

b. Do they manufacture and/or verify airborne products utilizing tools that are controlled by software or digital equipment?

c. Were changes related to Y2K anomalies necessary and/or implemented?

d. Would those changes impact aviation safety?

AIR received a response rate of greater than 97 percent from the aviation industry. Analysis of the responses provided by these manufacturers indicated that safety would not be impacted due to changes necessitated by Y2K problems.

AIR extended this survey to our bilateral partners in more than 20 countries, requesting the Civil Aviation Authorities (CAA) send the same, if not similar, survey to manufacturers for which they have regulatory oversight. We received a 90 percent response rate from these CAA. Again, based on the responses provided, AIR concluded that safety would not be impacted due to changes necessitated by Y2K problems at foreign-based manufacturers under CAA oversight.

2.2. TRANSITION SURVEY.

In 1998, the Office of the Inspector General (OIG) conducted an audit to evaluate AIR activities with regard to Y2K preparedness. The OIG identified a concern with the lack of follow-up activities addressed in the AIR Y2K Plan. To address this concern, the

Year 2000 Transition Survey was developed and conducted as part of the ongoing Aircraft Certification Systems Evaluation Program (ACSEP). The Transition Survey was comprised of twenty questions, and required objective evidence confirming all responses. The completed Transition Surveys where collected by Aircraft Engineering Division, AIR-100, and Production and Airworthiness Certification Division, AIR-200, personnel. In late 1998, an analysis of this data revealed three main areas of concern to AIR, the lack of testing, the lack of contingency plans, and risks associated with schedule slippage. AIR was concerned that insufficient activities, in testing, contingency planning, and scheduling, would increasing the potential for Y2K anomalies to impact aviation safety.

These concerns initiated a reassessment of the AIR Y2K Plan, and resulted in the development of AIR training and the conduct of AIR-100/AIR-200 and Directorate "on-site" Assessments.

2.3. AIR-100/AIR-200 ASSESSMENTS.

In 1999, AIR-100/AIR-200 personnel identified four "at-risk" companies based on analysis of responses provided in the Transition Survey. These companies were evaluated to validate or invalidate the concerns raised by the analysis of the Transition Survey data. The results of these evaluations did NOT substantiate that, due to potential Y2K anomalies, these manufacturers would produce products that did not meet the type design or that safety would be impacted. However, these assessments identified other non-critical issues that, if not corrected, could effect a Production Approval Holder’s (PAH) quality system.

Title 14, Code of Federal Regulations, part 21, Certification Procedures for Products and Parts, assigns each PAH the responsibility to establish and maintain a quality control system acceptable to the Administrator. The FAA grants production approvals based on the review and analysis of the quality control system documents. Information gathered during AIR-100/AIR-200 assessments of these companies indicated that Y2K anomalies could impact the PAH quality control system. Specifically, one of the facilities chosen provided data indicating that the manufacturer was experiencing schedule slippage in the correction and testing of key internal processes. Furthermore, this manufacture did not have a contingency plan, to address the possibility of further schedule slippage and to minimize impacts to their quality control system. While individual "nuisance" anomalies may have a minimal effect, several anomalies in key process areas (e.g., records, gage recall, configuration control) may increase the potential for a "compromised" quality control system. Additionally, the tendency to develop temporary "work around" procedures for these nuisance anomalies may cause products to be produced in a manner inconsistent with the FAA approved quality control system.

The identification of Y2K anomalies with the potential to impact the PAH quality control system, established a need to develop the training and tools necessary to enable the AIR workforce to conduct Y2K Assessments at various manufacturing facilities.

2.4. TRAINING.

The Aircraft Certification Service developed a Y2K Interactive Video Teleconference (IVT). The IVT was conducted on October 27, 1999, to provide standardized training to the Aviation Safety Inspector (ASI)/Aviation Safety Engineer (ASE) assessment team. This training provided the ASI and ASE with the information needed to assess potential Y2K problems associated with manufacturing, testing, and inspection, as they relate to product airworthiness. The IVT introduced and addressed such terms as pivot points, event driven triggers, impact analysis, windowing, expansion, testing (regression, integration, and system), and contingency planning. This IVT was developed to aid the ASI/ASE in making a determination of the Y2K preparedness level of a PAH, by ensuring that components susceptible to Y2K date anomalies have been identified, remediated, tested, and the changes recorded as applicable.

Technical staff from AIR-100/AIR-200 attended several initial directorate assessments. This provided an opportunity for additional "hands on" training for directorate personnel, promoting standardization in the conduct of Y2K assessments.

2.5. DIRECTORATE ASSESSMENTS.

As part of AIR's efforts to standardize the Y2K assessment process, the Aircraft Certification Service Y2K Surveillance Program Plan was generated. This plan documented the basis for AIR concerns regarding the Y2K rollover, and the process used to select and prioritize PAH facilities exhibiting possible Y2K risk mitigation inconsistencies (reference Appendix B). The plan also contained the Y2K Assessment Package, developed to provide guidance and tools to the ASI/ASE workforce, and to standardize conduct of the Y2K assessments. The Assessment Package was utilized to assess and record facility planning, process changes/updates, remediation efforts employed to decrease risks associated with the potential Y2K anomalies, testing, and contingency plans. All information obtained during the accomplishment of AIR assessments was collected outside of the YEAR 2000 INFORMATION AND READINESS DISCLOSURE ACT (reference Appendix A). The Assessment Package contained the following:

a. **<u>Assessment Methodology Guide.</u>** This guide details key review topics, areas of concern at a manufacturing facility, the concepts or strategies which can be employed to gain insight to facility planning and remediation, as well as information on "how" to chart and follow a course of evaluation during facility assessments.

b. <u>Assessment Approach Tool.</u> The assessment approach tool diagrams (via flowcharts) the procedures for conducting the Y2K assessment. It provides a snapshot of the criteria detailed in the methodology guide, complete with entry and exit decision points.

c. <u>Assessment Record.</u> The Y2K Assessment Record was created to enable Aircraft Certification Service personnel to assess and document pertinent Y2K information. This document details the assessment path, the validation and verification course undertaken at each facility, and insight to such things as degree of automation, Y2K impact on manufacturing and quality assurance processes and pivot points, etc. Completion of the Y2K Assessment Record provided a record of the results of the assessment and supports AIR analysis as to the "state of aviation manufacturing." Directorate personnel were requested to forward the completed Y2K Assessment Records to AIR-100/AIR-200 for analysis and generation of the Y2K Final Report.

3. PROGRAM RESULTS.

Directorate personnel applied the criteria detailed in the Aircraft Certification Service Y2K Surveillance Program Plan, and identified those facilities exhibiting the greatest risks associated with Y2K anomalies (reference Appendix B, priority 1 through 3). A total of 87 facilities were identified to be evaluated prior to March 31, 2000. Assessments began in November 1999 and continued through February 2000. The smooth transition to the year 2000 with no adverse impacts on aviation safety, indicated that the aviation manufacturing industry has taken adequate steps to mitigate potential Y2K anomalies. Based on recommendations provided by Directorate personnel and substantiated by review of the "Assessment Records," AIR discontinued the Y2K assessments in March 2000. Directorate personnel accomplished Y2K Assessments in 35 facilities, prior to AIR discontinuance.

The Assessment Records, generated from the Y2K assessments, were reviewed and provide the basis for the following conclusions.

4. CONCLUSIONS.

All facilities assessed indicated that some level of risk assessment had been performed. Of the facilities assessed, 80 percent provided a documented inventory of all automation/software used in their facility. Additionally, a review of those inventories indicated that critical processes had been identified for 75 percent of those facilities with documented inventories.

Of facilities assessed, 37 percent indicated that some type of "work around" or minor change to a process or procedure was necessary, due to anomalies associated with Y2K.

The manufacturer and/or the FAA assessor(s) provided notification of these changes to the responsible Principle Inspector (PI).

Only two assessments indicated any issues with regard to the testing accomplished by the manufacturers. In both cases, corrective action was accomplished and follow-up activities identified.

Three assessments indicated concerns in the control of suppliers. The manufacturers had not accomplished follow-up activities for suppliers that failed to respond to the manufacturer's Y2K Survey, and/or responded negatively. When identified during the FAA Y2K Assessment, corrective action was identified and notification provided to the PI for verification.

No issues were identified with regard to methods of remediation (correction). However, "windowing" techniques (reference Appendix C) were employed in 43 percent of these facilities. This method of remediation does not correct the date data, but rather it “moves” the problem out several years, providing additional time to implement a more permanent solution. The amount of time provided is defined by the size of the "window" or the pivot point. Fortunately, those pivot points identified during AIR assessments are greater than or equal to thirty years, delaying most date anomalies until 2029. Information detailing the methods of remediation and the assignment of pivot points (where applicable) has not been identified for most commercial software applications (e.g., shrink-wrap, off-the-shelf, and embedded types of software). The manufacturers of these products provide Y2K Compliance Statements and software "patches" where applicable. It is most likely that the software application will be replaced well in advance of the reoccurrence of date anomalies. However, the absence of "triggers" to alert the user of the expiration of these windows/pivot points is an AIR concern. To maintain FAA and industry focus on this issue, AIR will perform a survey in FY05 to validate or invalidate this concern.

The intermittent characteristics of the Crouch Echlin Effect, have also been identified as a source of AIR concern. However, the increased awareness of this anomaly, obtained through AIR training and accomplishment of Y2K assessments, has significantly reduced the potential for this anomaly to go undetected.

APPENDIX A
YEAR 2000 INFORMATION AND READINESS DISCLOSURE ACT (IRDA)

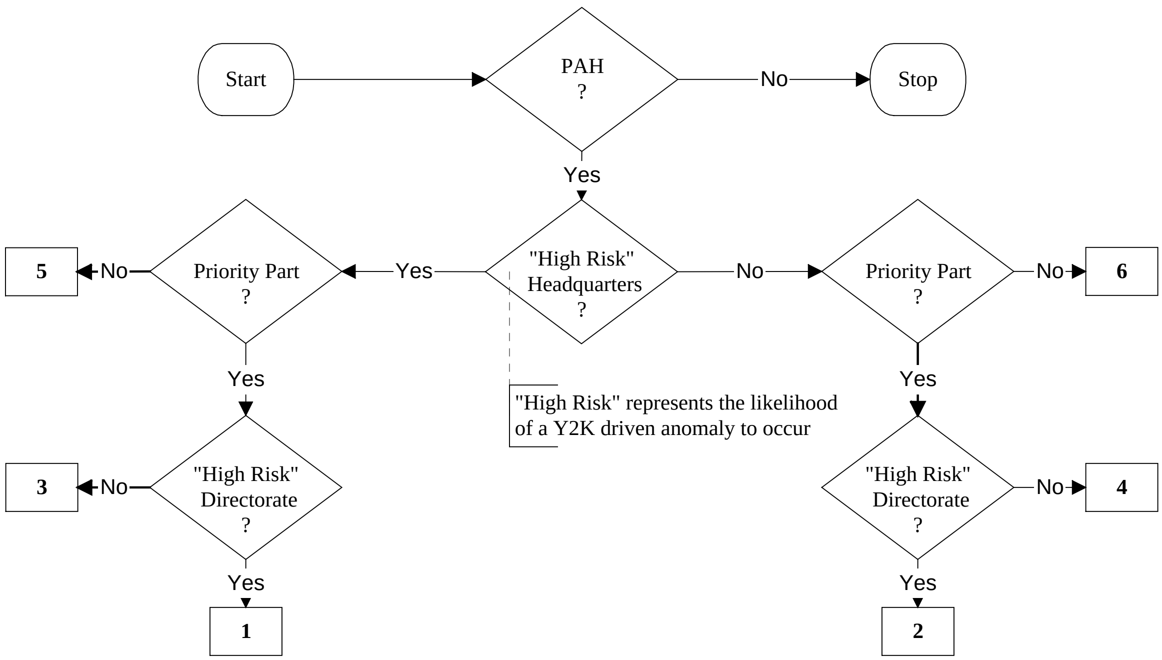
Referred to as the *Good Samaritan Act,* its purpose is to; (1) promote the free disclosure and exchange of information related to Year 2000 readiness; (2) assist consumers, small businesses, and local governments in effectively and rapidly responding to Year 2000 problems; and (3) lessen burdens on interstate commerce by establishing certain uniform legal principles in connection with the disclosure and exchange of information related to Year 2000 readiness.

A Federal entity, agency, or authority may expressly designate a request for the voluntary provision of information relating to Year 2000 processing, including Year 2000 statements, as a special Year 2000 data gathering request made pursuant to subsection 4(f) of the IRDA.

The FAA, as a regulatory agency, does not accept information provided under the IRDA and will not solicit information under the IRDA. As AIR has collected its Year 2000 information solely outside the IRDA, manufacturers cannot unilaterally claim protection of the IRDA when providing the FAA with Year 2000 information.

APPENDIX B
FACILITIES SELECTION DIAGRAM

The following diagram represents the selection process used to prioritize and categorize facilities for Y2K assessments. Facilities must have been designated as a PAH and were required to either utilize software within their production, records, quality assurance, or design processes and/or produce software used in airborne products/equipment.



NOTE: "Priority Part" means any part (including assemblies) in an FAA-approved design that, if it were to fail, could reasonably be expected to cause an unsafe condition in an aircraft, engine, or propeller.

Priority 1– Production Approval Holder (**PAH**) facilities, assessed by Headquarters as **"High Risk,"** producing a **Priority Part**, and verified by the Directorate as **"High Risk."**

Priority 2 – **PAH** facilities, not assessed by Headquarters, producing a **Priority Part,** assessed by the Directorate as **"High Risk."**

Priority 3 – **PAH** facilities, assessed as **"High Risk"** by Headquarters, producing a **Priority Part**, reassessed by the Directorates as other than "High Risk."

Priority 4 – **PAH** facilities, not assessed by Headquarters, producing a **Priority Part,** assessed by Directorates as other than "High Risk."

Priority 5 – **PAH** facilities, assessed as **"High Risk"** by Headquarters, not producing priority parts.

Priority 6 – **PAH** facilities, not assessed by Headquarters, not producing priority parts.

APPENDIX C
CONVERSION APPROACHES

There are two commonly used conversion approaches, date field expansion and windowing, implemented to correct or mitigate Y2K anomalies. Date field expansion takes the existing two-digit date field (containing only year data), and expands it to a four-digit date field. This enables storage of the year and century data (i.e., 1999). The date field expansion approach is a permanent "fix," requiring minimal changes to date processing logic, easy identification of failures, and no continuous maintenance activities. However, date field expansion also requires more initial resources to modify data and program files, simultaneous conversion of all related programs or the building of "temporary bridges," and maintaining any applicable conversion programs to enable processing of historical data that has not been converted. This conversion approach can be, at least in the short term, quite costly. As a result, many companies have elected to implement the windowing approach.

The window conversion approach is based on the concept that two-digit date misinterpretation may occur every 100 years, and that a software application can be written to accommodate this occasional misinterpretation. Furthermore, based on the current rate of development, the software/computer programs will probably be obsolete by the time this occurs. Windowing does not correct the date data, but rather it “moves” the problem out several years, providing additional time to implement a more permanent solution. The windowing approach results in the generation of software code, internal to the software application (e.g., Microsoft Excel), that provides interpretation of the correct century from the two-digit date field. This interpretation is derived from the application of a fixed or sliding window, the size of which is defined by the developer and referred to as a pivot point. Dates within the window are interpreted as one century, and all others are interpreted as the other century. For example, a software application with a pivot point of "20" might interpret the two-digit dates "00" through "19" as 2000-2019, and "20" through "99" as 1920-1999.

Of primary concern, is the lack of standardization in the assignment of pivot points and the lack of documentation identifying what pivot point has been implemented. The British Standards Institute recommends a pivot point of 50, however varying pivot points have been implemented for software applications and/or different versions of the same software application. When data is shared between software applications with different pivot points, it can cause a corruption of data within the range of time between the established pivots (e.g., software #1 has a pivot of "20" and software #2 has a pivot of "30", the problem range would be 20-29).

The lack of standardization in assignments of pivot points, coupled with the failure to document and inform the end-user of an approaching pivot point can provide corruption of data/anomalies indefinitely.

APPENDIX D
CROUCH ECHLIN EFFECT

1. Introduction. The Crouch Echlin Effect is a post year 2000 problem that can affect computer systems whether or not they are year 2000 compliant.

2. Background. When a personal computer (PC) is switched on, the Basic Input Output System (BIOS) needs to access the Real Time Clock to get date and time information to allow correct synchronization with the PC's operating system. Before the BIOS can get date and time information from the Real Time Clock, it has to check whether this information is in the process of being updated. To do this, it checks a flag (or semaphore) generated by the Real Time Clock. The BIOS can only read the date/time data if this information is not being updated. If the update flag indicates that the date/time information is being updated, the BIOS will wait until the update process is complete before reading the information. Although this is a reliable safeguard, the designers of Real Time Clocks realized that two additional facts should be accounted for:

a. It is possible that, even though the Real Time Clock was not updating its information when the BIOS started to read the date and time, it could start its update process while the BIOS is reading this information. This is particularly true for BIOS systems that have complex algorithms to get the date and time.

b. Few BIOS systems actually check that the date/time information read from the Real Time Clock is valid. This means that, if the date/time information is updated while the BIOS is reading it, the BIOS could pass corrupted/non-validated information to other systems. To address this problem, the designers of Real Time Clocks calculated the maximum time it could take a BIOS system to read the date/time and set the Real Time Clock update flag that much earlier (244 micro seconds). This provides the BIOS with sufficient time to read and validate the date/time information.

3. How Does This Lead To The Crouch Echlin Effect? Any changes to software, made as a result of Y2K anomalies, may effect the amount of time it takes to calculate date information. If the BIOS takes more than 244 micro seconds to read and process the date/time, it is possible that it will attempt to read this information while it is being updated (as discussed above). This could result in corrupted information that may not be validated by the BIOS, and may be transferred to other systems.

4. What are the symptoms of the problem? The symptoms of these problems are intermittent sudden jumps in the date or time. Specifically, a sudden jump forward in time/date, or a sudden jump backward to an arbitrary fault date.

5. Are any systems immune to this problem? This does not occur in systems where the Real Time Clock has been double buffered. Double buffering is a process of giving a system that provides information to other systems, two separate data stores or buffers. The first is a "read" data store/buffer for other systems to read information from, and the second is a "update" data store/buffer.

The contents of the "update" data store/buffer are updated bit by bit (in the software background) and then transferred to the "read" data store/buffer.

If the Real Time Clock is double buffered, the BIOS system will be able to read stable, uncorrupted information from the "read" buffer while the Real Time Clock is updating the information in the "update" buffer. Once the information in the update buffer has been completely updated, it takes almost no time to transfer the information from one buffer to the other. This means that it is virtually impossible for the date/time information to be updated while the BIOS is reading it.

6. General Information.

Double buffering is the only proven method of correction. In NON critical applications, resetting the computer may result in a successful update of date/time information, as well as manually resetting the date/time information. Whether this problem occurs or not is primarily dependent upon when the BIOS tries to read the date/time information. This can happen at any time, during the Real Time Clock update cycle (approximately one second), and it is very difficult to force or predict an occurrence. Consequently, identification and correction of this anomaly has been extremely difficult.